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NATIONAL DAM INSPECTION PROGRAM. BEAVER LAKE DAM (NDS I.D. NUMB--ETC(U)
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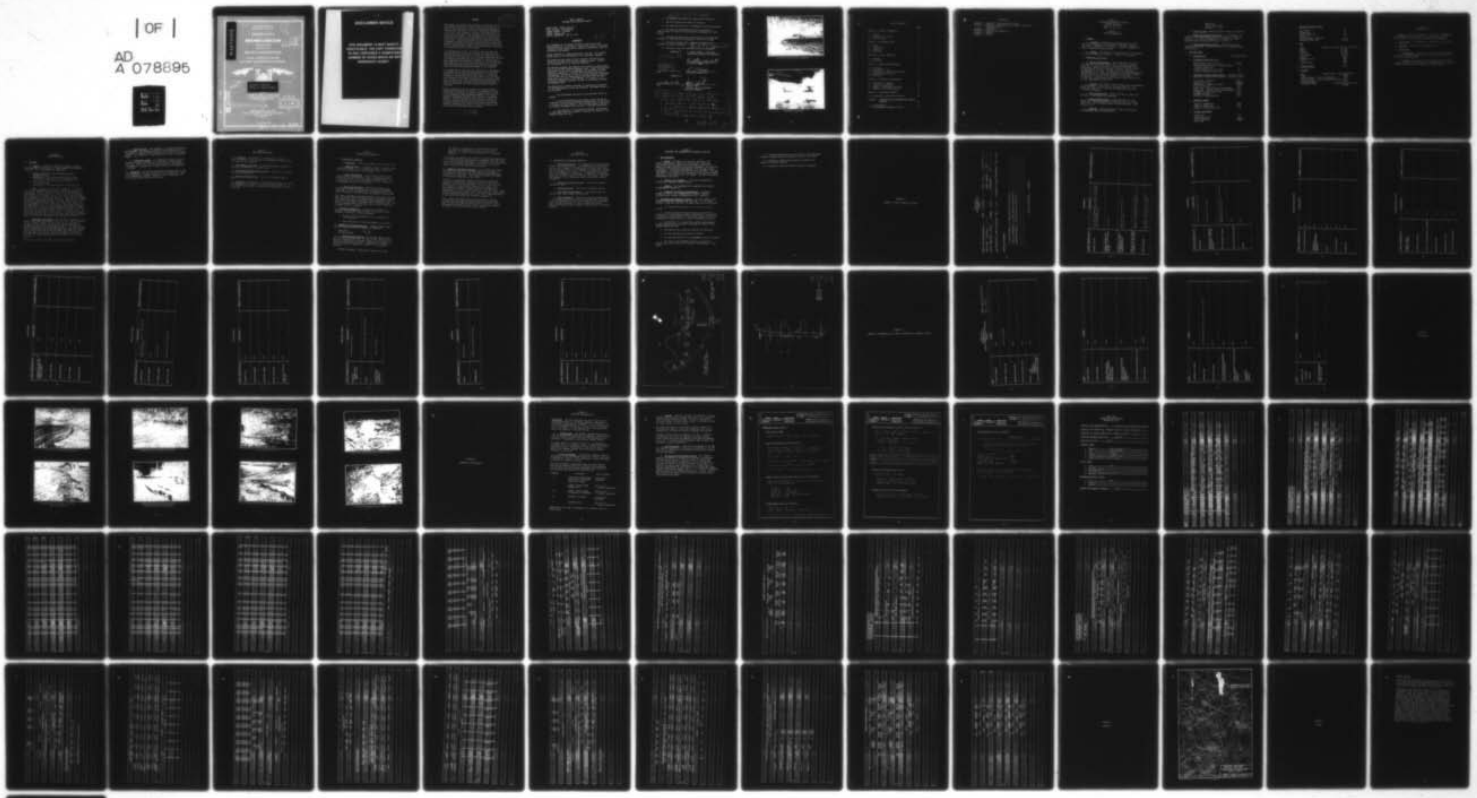

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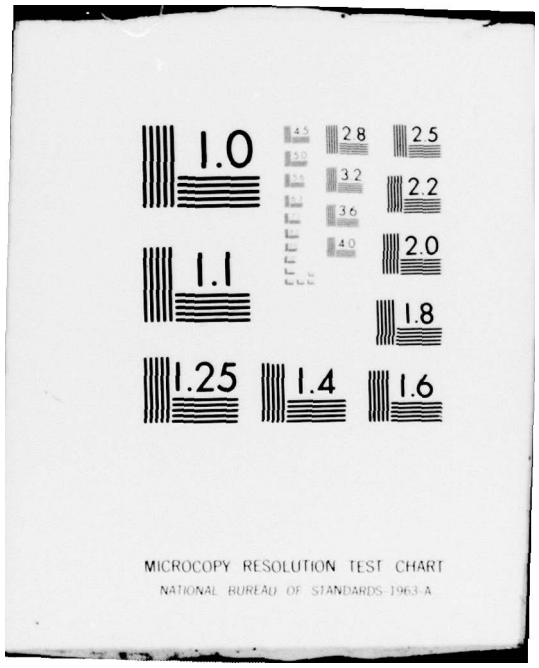
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PENNSYLVANIA

BEAVER LAKE DAM

BEAVER LAKE ENTERPRIZES

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

AUGUST 1978

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I REPORT
NATIONAL DAM INSPECTION REPORT

NAME OF DAM: Beaver Lake Dam
STATE LOCATED: Pennsylvania
COUNTY LOCATED: Lycoming
STREAM: Beaver Run
DATE OF INSPECTION: May 24, 1979

ASSESSMENT

The assessment of the Beaver Run Dam is based upon visual observations made at the time of inspection, review of available records and data, hydrology and hydraulic computations, and past operational performance.

Beaver Lake Dam is a high hazard-small size dam. The Spillway Design Flood is the PMF because of the downstream exposure.

The inspection and review of data of Beaver Lake Dam did not reveal any problems which require emergency action. However, the dam appears to be in very poor condition.

The existing spillway and reservoir are capable of passing less than 1% of the PMF (Probable Maximum Flood). Based upon criteria established by the Corps of Engineers, the spillway is termed seriously inadequate. If Beaver Lake Dam should fail due to overtopping, the hazard to loss of life and property downstream from the dam would be significatnly increased from that which would exist just prior to overtopping. As a result of the seriously inadequate spillway, the dam is considered an unsafe, non-emergency dam.

The owner should consider breaching or removing the structure. If the owner desires to keep the structure, the owner should do the following:

1. The flashboards and debris in the spillway should be removed.

2. A detailed hydrologic and hydraulic study should be conducted by a professional engineer knowledgeable in dam design to increase spillway capacity. The spillway capacity should be increased in accordance with the Corp of Engineers guidelines.

3. The services of a professional engineer knowledgeable in dam design should be retained to evaluate the effect of the seepage through the dam.

(15) DACW31-79-C-0009

4. The concrete wall should be repaired and stabilized.

5. The left spillway wall should be repaired.

6. All holes and erosion of the embankment should be repaired.

7. The trees on the embankment should be selectively removed under the direction of an engineer knowledgeable in dam design.

8. A warning system should be instituted to warn downstream residents or large spillway discharges or failure of the dam.

9. Institute a formal safety inspection program to be conducted at reulgar intervals.

(10) R. Jeffrey Kimball

10. A method to drain the reservoir should be developed.

SUBMITTED BY:

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS AND ARCHITECTS

(11) Aug 79

R Jeffrey Kimball

R. Jeffrey Kimball, P.E.

(12) 82

K. Chuang

Date

Kuang-hwei Chuang, P.E.

APPROVED BY:

16 Aug. 1979

James W. Peck

Date

JAMES W. PECK
Colonel, Corps of Engineers
District Engineer

(6) National Dam Inspection Program. Beaver Lake Dam (NDS I.D. Number PA-354, DER I.D. Number 41-10), Beaver Lake Enterprises, Susquehanna River Basin, Beaver Run, Lycoming County, Pennsylvania. Phase I Inspection Report,

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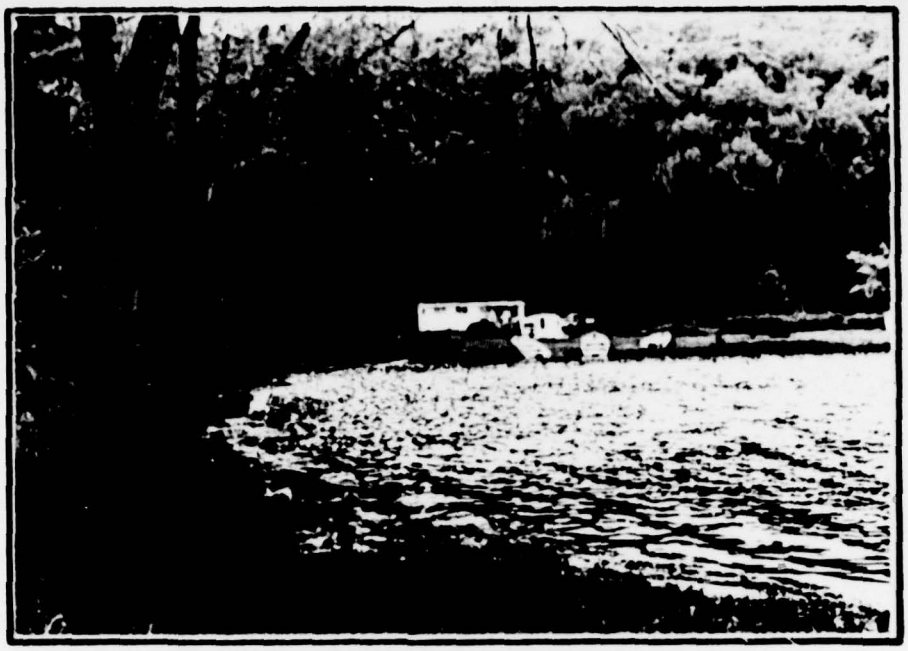

Overview of dam from left abutment.

Overview of spillway.

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APPENDICES

PHASE I
NATIONAL DAM INSPECTION PROGRAM
BEAVER LAKE DAM
NDI I.D. NO. PA 354
DER I.D. NO. 41-10

SECTION 1
PROJECT INFORMATION

1.1 General.

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose. The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project.

a. Dam and Appurtenances. Beaver Lake Dam is an earth-fill dam with a vertical concrete wall forming the upstream slope and a vertical stone wall forming the downstream slope. The material between the two walls is earth. The crest width is approximately 12 feet. The dam is 179 feet long and approximately 9 feet high. The dam crest is curved concaved in an upstream direction. The right abutment is very gently sloping. The spillway is located in the center of the dam and is 19 feet long. There are no outlet pipes or drain facilities in the dam. ~~(See pages A-12 and A-13).~~

b. Location. The dam is located on Beaver Run, approximately 3.5 miles south of Muncy Valley, Lycoming County, PA. The Beaver Lake Dam can be located on the Sonestown PA U.S.G.S. 7.5 minute quadrangle.

c. Size Classification. Beaver Lake Dam is a small size structure (9 feet high, 370 acre-feet).

d. Hazard Classification. Beaver Lake Dam is a high hazard dam. Downstream conditions indicate that loss of more than a few lives is probable should the structure fail. (See section 3.1e).

e. Ownership. Beaver Lake Dam is owned by Ned Rettew. Correspondence should be addressed to:

Ned Rettew
308 N. State Street
Ephrata, PA 17522

f. Purpose of Dam. Beaver Lake Dam is used for recreation.

g. Design and Construction History. No information is available on the design and construction history. Inspection reports in the files of Commonwealth of Pennsylvania, DER indicated that the dam was built prior to 1919.

h. Normal Operating Procedures. There are no normal operating procedures. Inflow to the dam is discharged through the spillway.

1.3 Pertinent Data.

a. Drainage Area. 2.96 square miles

b. Discharge at Dam Site (cfs).

Maximum known flood at dam site	Unknown
Spillway capacity at top of dam elevation existing conditions	5
Spillway capacity at top of dam without flashboards and debris	348

c. Elevation (U.S.G.S. Datum) (feet). - Elevation worked from top of concrete wall adjacent to spillway (900.0).

Top of dam - low point	899.8
Design top of dam	Unknown
Maximum pool - design surcharge	Unknown
Full flood control	N/A
Normal pool - with debris and flashboards	899.6
Normal pool - without debris and flashboards	896.6
Streambed at centerline of dam	891.0
Maximum tailwater	None
Elevation of downstream toe	891.0

d. Reservoir (feet).

Length of maximum pool	6000
Length of normal pool	4400
Length of flood control pool	N/A

e. Storage (acre-feet).

Normal pool	370
Flood control pool	N/A
Design Surcharge	Unknown
Top of dam	370

f. Reservoir Surface (acres).

Top of dam	65
Maximum pool	72
Flood control pool	N/A
Normal pool	65
Spillway crest - existing	65
Design spillway crest	Unknown

g. Dam.

Type	Earthfill with concrete and stone walls
Height	9 feet
Length	179 feet
Top width	12 feet
Side slopes	Vertical
Zoning	None
Impervious core	None
Cutoff	None
Grout curtain	None

h. Reservoir Drain. None

i. Spillway.

Type	Uncontrolled - broad crested weir
Length	19 feet
Crest Elevation - without flashboards	896.6
Crest Elevation - with flashboards and debris	899.6
Upstream channel	Lake
Downstream channel	Approximate 100 foot long channel

SECTION 2 .
ENGINEERING DATA

2.1 Design. Review of information in the files of Commonwealth of Pennsylvania, DER revealed that no construction drawings, design reports or other design information were available.

2.2 Construction. No information on construction is available.

2.3 Operation. There are no operating records.

2.4 Evaluation.

a. Availability. Same data on previous inspections were provided by Pennsylvania DER, Bureau of Dam Safety, Obstructions and Storm Water Management.

b. Adequacy. The amount of design and construction data is very limited. The information, in conjunction with the onsite inspection, is sufficient to complete a Phase I Report.

SECTION 3
VISUAL INSPECTION

3.1 Findings.

a. General. The onsite inspection of Beaver Lake Dam was conducted by personnel of L. Robert Kimball and Associates on May 24, 1979. The inspection consisted of:

1. Visual inspection of the retaining structure, abutments and toe.
2. Examination of the spillway facilities, portions of any outlet works, and other appurtenant works.
3. Observations affecting the runoff potential of the drainage basin.
4. Evaluation of the downstream area hazard potential.

b. Dam. The dam is in very poor condition. The concrete wall on the upstream slope is broken, cracked, deteriorated and leaning. Part of the wall to the left of the spillway has been washed out (See page A-13). To the right of the spillway most of the wall is leaning and may fail. The stone wall forming the downstream slope is in fair condition. Near the left abutment are several large trees growing on the dam. Near station 3 + 05 water is seeping through or under the concrete wall and up onto the embankment crest. The water in then flowing over the crest and down through a hole in the embankment and eventually through the stone wall. The crest varies from elevation 899.8 to 900.2. Water level at the time of inspection was at elevation 899.7. Wave action was carrying water over the crest. In addition, a breach in the spillway left wall was carrying more water over the embankment to the left of the spillway than through the spillway.

c. Appurtenant Structures. The spillway is located in the center of the dam. The concrete crest is 3 feet (896.6) below top of dam. However, during the inspection several flashboards and debris in the form of sticks, brush and tires blocked the spillway making the crest approximately 899.6. The left spillway wall is deteriorated and during the inspection water was flowing over the dam to the left of the spillway. Wave action was also carrying water over the dam. The left abutment of the dam is very flat and during high reservoir there may be flow over this portion.

There are no drains in the dam to lower the water level.

d. Reservoir Area. The watershed is covered with woodland and farmland. The reservoir slopes are not considered to be susceptible to massive landslides which would affect the storage volume of the reservoir or overtopping of the dam by displacing water.

e. Downstream Channel. The downstream channel of Beaver Run below the dam is narrow for a distance of approximately 3000 feet. Below 3000 feet the channel widens. Approximately 5 residences (20 people) are located within 2 miles downstream of the dam.

3.2 Evaluation. The dam and appurtenant structures are in very poor condition. The poor condition of the concrete wall, holes in the embankment, seepage, vegetation on the embankment, and the blocked spillway should be corrected.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures. The reservoir is maintained at as high a level as possible. Excess inflow is discharged over the spillway. No operations are conducted.

4.2 Maintenance of the Dam. No planned maintenance schedule is utilized. Maintenance of the dam is poor.

4.3 Maintenance of Operating Facilities. There are no operating facilities (drainlines).

4.4 Warning System in Effect. There is no warning system in effect.

4.5 Evaluation. Maintenance of the dam and appurtenant structures is considered poor. There is no warning system in effect to warn downstream residents of large spillway discharges or failure of the dam.

SECTION 5
HYDRAULICS AND HYDROLOGY

5.1 Evaluation of Features.

a. Design Data. There is no hydraulic and hydrology data.

b. Experience Data. No rainfall, runoff or reservoir level data were available. It is reported that debris periodically blocks the spillway until a flood washes it out.

c. Visual Observations. The spillway has several flashboards placed to increase water level. In addition, debris blocked the spillway further increasing the water level. The left spillway wall is broken and water flows over a portion of the embankment adjacent to the spillway.

d. Overtopping Potential. Overtopping potential was investigated through the development of the probable maximum flood (PMF) for the watershed and the subsequent routing of the PMF and fractions of the PMF through the reservoir and spillway.

The Corps of Engineers, Baltimore District, has directed that the HEC-1 Dam Safety Version systemized computer program be utilized. The program was prepared by the Hydrologic Engineering Center (HEC), U.S. Army Corps of Engineers, Davis, California, July, 1978. The major methodologies or key input data for this program are discussed briefly in Appendix D.

5.2 Evaluation Assumptions. To enable us to complete the hydraulic and hydrologic analysis for this structure, it was necessary to make the following assumptions.

1. Spillway crest was assumed to be at elevation 899.6 (top of debris).

2. Water level prior to flood was assumed to be at 899.6.

5.3 Summary of Overtopping Analysis. Complete summary sheets from the computer output are presented in Appendix D.

Peak inflow	6564 cfs
Spillway capacity	5 cfs

a. Spillway Adequacy Rating. The Spillway Design Flood (SDF) for this dam is the PMF. The SDF is based upon the hazard and size classification of the dam. Based on the following definition provided by the Corps of Engineers, this spillway is rated as seriously inadequate as a result of our hydrologic analysis.

Seriously Inadequate - High hazard classification dams

not capable of passing 50% of the PMF without failure when there is a significant increase in the hazard potential for loss of life downstream due to overtopping failure.

The spillway and reservoir are capable of controlling approximately 1 % of the PMF without overtopping the embankment under the conditions noted during the inspections. In addition, it was determined that if the flashboards and debris were removed the spillway capacity would not be increased significantly.

5.4 Summary of Dam Breach Analysis. As the subject dam cannot satisfactorily pass 50% of the PMF (based on our analysis) it was necessary to perform a dam breach analysis and downstream routing of the flood wave. This analysis determines the degree of increased flooding due to dam failure.

Results of the Dam Breach Analysis indicate that downstream flooding is significantly increased. Failure of the dam was assumed to occur with approximately 0.6 foot of water over the dam. Because of the very poor condition of the dam, a near full breach was assumed. Maximum flood level increase was approximately 3.4 feet with an increase of 1,000 cfs (167%). These results indicate that failure due to overtopping will significantly increase downstream potential for loss of life. Detailed results of the flood wave routing are included in Appendix D.

Note: Future development within the watershed, at the dam, or downstream may change the characteristics and assumptions made for this study and different results are likely. Future development downstream may also greatly increase the potential for loss of life due to failure of the structure.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability.

a. Visual Observations. The concrete wall on the upstream slope is tilting and failing. The embankment has several holes in the crest. Seepage is flowing under or through the concrete wall and through holes in the embankment and stone wall. Several trees are growing on the crest. If the wall should completely fail, the embankment is jeopardized. In addition, the potential exists for a piping problem to develop in the future. Therefore the embankment is not considered stable under static loading conditions.

b. Design and Construction Data. There are no design or construction data.

c. Operating Records. There are no operating records.

d. Post Construction Changes. It is reported that the first spillway was a timber crib structure.

e. Seismic Stability. The dam is located in seismic zone 1. No seismic stability analysis has been performed. Normally, it can be considered that if a dam in this zone is stable under static loading conditions, it can be assumed safe for any expected earthquake loading, however, this structure is presently unstable.

SECTION 7
ASSESSMENT AND RECOMMENDATIONS/REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety. The dam is in very poor condition. The visual observations, review of available data, hydrologic calculations and past operational performance indicate that Beaver Lake Dam's spillway is seriously inadequate. The spillway is capable of controlling approximately 1% of the PMF without overtopping. No stability analysis has been performed. The long term effect of the stability is uncertain due to the questionable stability of the concrete wall and seepage. The dam is an unsafe non-emergency structure.

b. Adequacy of Information. Sufficient information is available to complete a Phase I Report.

c. Urgency. The recommendations suggested below should be implemented immediately.

d. Necessity for Further Investigation. In order to accomplish some of the recommendations/remedial measures outlined below, further investigations will be required.

7.2 Recommendations/Remedial Measures. The dam's owner should consider breaching or removing the structure. If the owner decides to keep the structure, the owner should do the following:

1. The flashboards and debris in the spillway should be removed.

2. A detailed hydrologic and hydraulic study should be conducted by a professional engineer knowledgeable in dam design to increase spillway capacity. The spillway capacity should be increased in accordance with the Corps of Engineers guidelines.

3. The services of a professional engineer knowledgeable in dam design should be retained to evaluate the effect of the seepage through the dam.

4. The concrete wall should be repaired and stabilized.

5. The left spillway wall should be repaired.

6. All holes and erosion of the embankment should be repaired.

7. The trees on the embankment should be selectively removed under the direction of an engineer knowledgeable in dam design.

8. A warning system should be instituted to warn downstream residents of large spillway discharges or failure of the dam.

9. Institute a formal safety inspection program to be conducted at regular intervals.

10. A method to drain the reservoir should be developed.

APPENDIX A

CHECKLIST, VISUAL INSPECTION, PHASE I

CHECK LIST
VISUAL INSPECTION
PHASE I

NAME OF DAM Beaver Lake Dam COUNTY Lycoming STATE PA ID# PA 354

TYPE OF DAM Earthfill HAZARD CATEGORY High

DATE(s) INSPECTION 5/24/79 WEATHER Cloudy TEMPERATURE 60's

POOL ELEVATION AT TIME OF INSPECTION 899.7 M.S.L. TAILWATER AT TIME OF INSPECTION None M.S.L.

INSPECTION PERSONNEL:

R. Jeffrey Kimball - L. Robert Kimball and Associates

James T. Hockensmith - L. Robert Kimball and Associates

Kuang Hwei Chuang - L. Robert Kimball and Associates

James T. Hockensmith RECORDER

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	No cracks in embankment - several large holes in crest present. Several cracks in concrete wall on upstream face.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None noted.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Some erosion of crest where water may have eroded.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Dam is curved in upstream direction. Vertical - crest uneven see pages A-12, A-13.	
RIPRAP FAILURES	No riprap - concrete wall on upstream partially failed and deteriorated.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
VEGETATION	Several trees growing on crest.	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Left spillway wall failed.	
ANY NOTICEABLE SEEPAGE	Seepage under concrete wall and through embankment and stone wall.	
STAFF GAUGE AND RECORDER	None.	
DRAINS	None.	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	N/A	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	N/A	
DRAINS	N/A	
WATER PASSAGES	N/A	
FOUNDATION	N/A	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	N/A	
STRUCTURAL CRACKING	N/A	
VERTICAL AND HORIZONTAL ALIGNMENT	N/A	
MONOLITH JOINTS	N/A	
CONSTRUCTION JOINTS	N/A	
STAFF GAUGE OR RECORDER	N/A	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	N/A	
INTAKE STRUCTURE	N/A	
OUTLET STRUCTURE	N/A	
OUTLET CHANNEL	N/A	
EMERGENCY GATE	N/A	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Fair condition - several flashboards and debris in spillway.	
APPROACH CHANNEL	Lake.	
DISCHARGE CHANNEL	Fair condition.	
BRIDGE AND PIERS	Bridge about 120' downstream.	

GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	N/A	
APPROACH CHANNEL	N/A	
DISCHARGE CHANNEL	N/A	
BRIDGE AND PIERS	N/A	
GATES AND OPERATION EQUIPMENT	N/A	

DOWNSTREAM CHANNEL

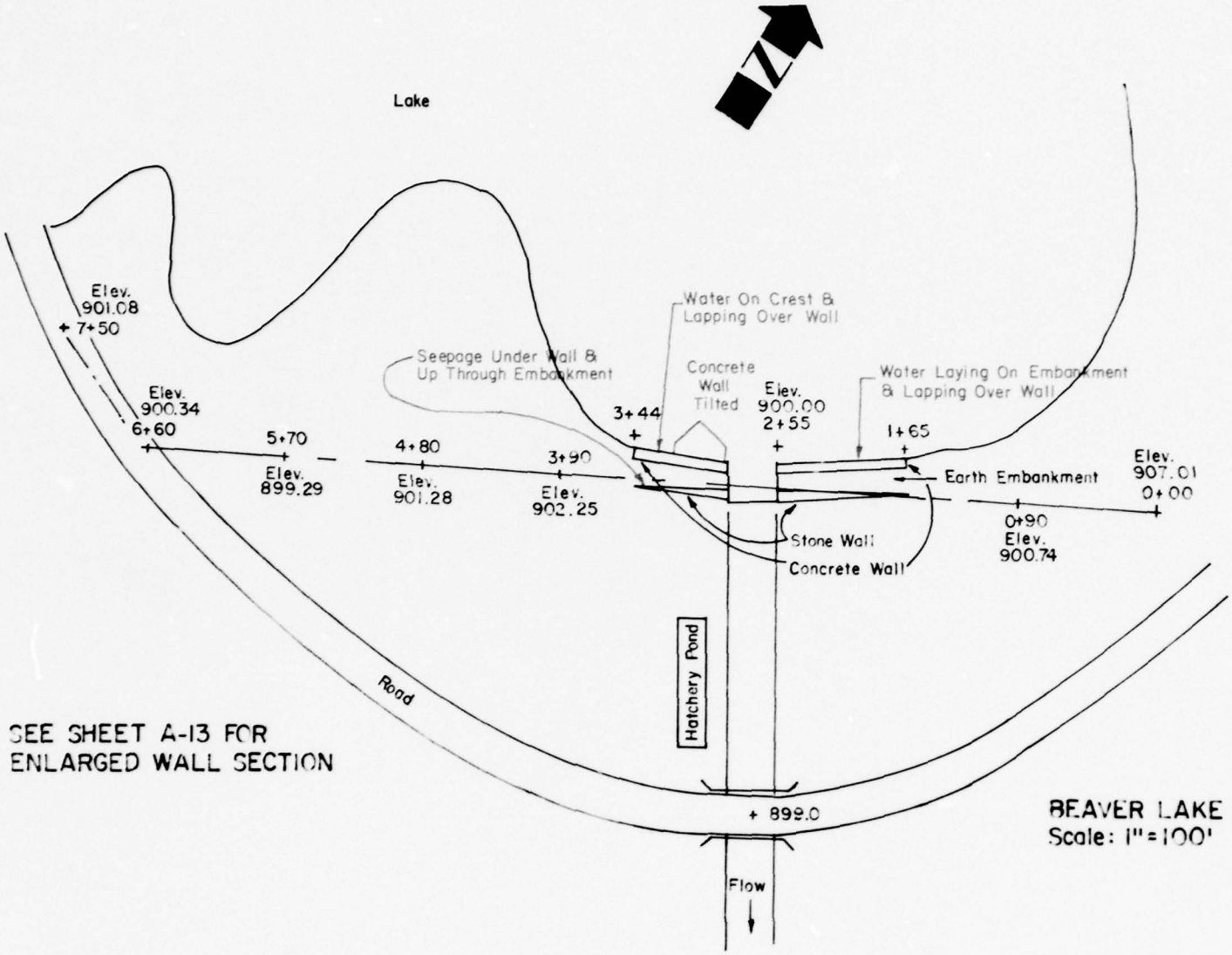
VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	No obstructions noted.	
SLOPES	Stone wall to below bridge 120'downstream.	
APPROXIMATE NO. OF HOMES AND POPULATION	5 homes (20 people).	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Appear stable.	
SEDIMENTATION	Sedimentation appears to be high.	

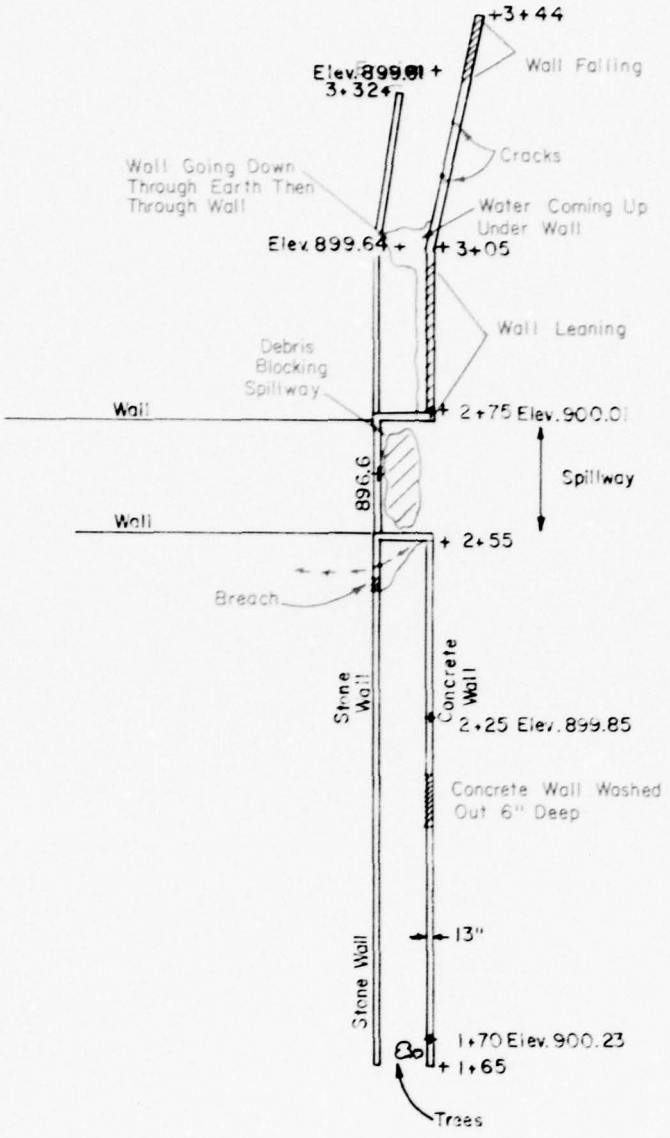
INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None.	
OBSERVATION WELLS	None.	
WEIRS	None.	
PIEZOMETERS	None.	
OTHER	None.	



SEE SHEET A-13 FOR
ENLARGED WALL SECTION

BEAVER LAKE DAM
Scale: 1"=100'



SHEET A-13
BEAVER LAKE DAM
Scale : 1" = 30'

APPENDIX B

CHECKLIST, ENGINEERING DATA, DESIGN, CONSTRUCTION, OPERATION, PHASE I

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM Beaver Lake Dam

ID# PA 354

ITEM	REMARKS
AS-BUILT DRAWINGS	None.
REGIONAL VICINITY MAP	U.S.G.S. quadrangle.
CONSTRUCTION HISTORY	None.
TYPICAL SECTIONS OF DAM	None.
OUTLETS - PLAN - DETAILS - CONSTRAINTS - DISCHARGE RATINGS RAINFALL/RESERVOIR RECORDS	None.

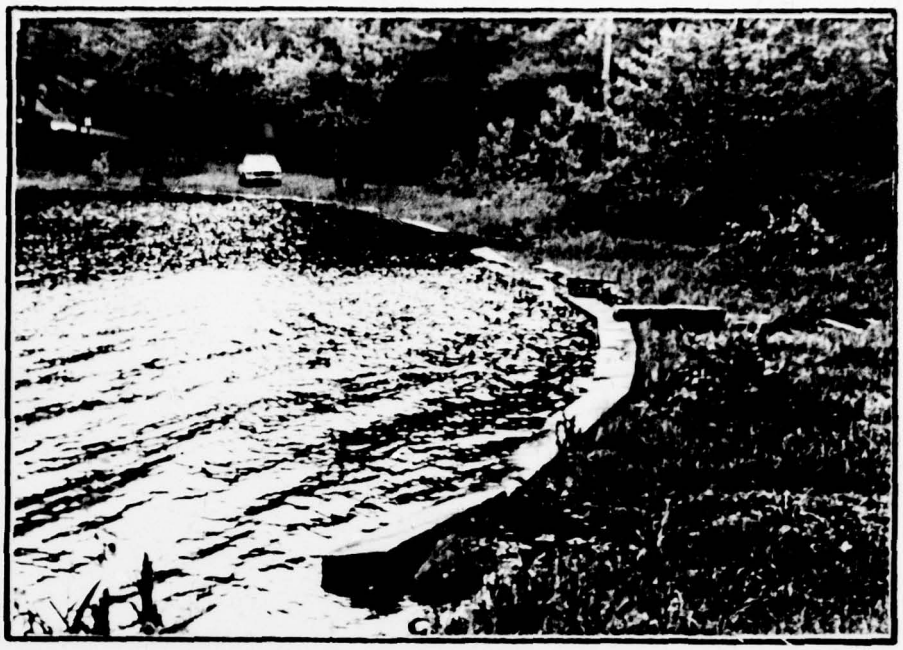
ITEM	REMARKS
DESIGN REPORTS	None.
GEOLOGY REPORTS	None.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	None.
POST-CONSTRUCTION SURVEYS OF DAM	None.
BORROW SOURCES	Unknown.

ITEM	REMARKS
MONITORING SYSTEMS	None.
MODIFICATIONS	Spillway modification from a timber crib structure.
HIGH POOL RECORDS	None.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None.
MAINTENANCE OPERATION RECORDS	None.

ITEM	REMARKS
SPILLWAY PLAN SECTIONS DETAILS	None.
OPERATING EQUIPMENT PLANS & DETAILS	None.

APPENDIX C

PHOTOGRAPHS



Concrete wall from right end of dam.

Concrete wall to the left of spillway.
Note no freeboard.

Downstream view of dam and stone wall.

Downstream view of dam and stone wall.
Note fish hatchery in foreground.

Debris blocking spillway.

Debris blocking spillway and water flowing around spillway.

Stone wall forming downstream slope of dam.

Stump on embankment at stone wall.

APPENDIX D

HYDROLOGY AND HYDRAULICS

APPENDIX D
HYDROLOGY AND HYDRAULICS

Methodology. The dam overtopping and breach analyses were accomplished using the systemized computer program HEC-1 (Dam Safety Investigation), September, 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California. A brief description of the methodology used in the analysis is presented below.

1. Precipitation. The Probable Maximum Precipitation (PMP) is derived and determined from regional charts prepared from past rainfall records including "Hydrometeorological Reports No. 40 prepared by the National Weather Service.

The index rainfall is reduced from 10% to 20% depending on watershed size by utilization of what is termed the HOP Brook adjustment factor. Distribution of the total rainfall is made by the computer program using distribution methods developed by the Corps.

2. Inflow Hydrograph. The hydrologic analysis used in development of the overtopping potential is based on applying a hypothetical storm to a unit hydrograph to obtain the inflow hydrograph for reservoir routing.

The unit hydrograph is developed using the Snyder method. This method requires calculation of several key parameters. The following list gives these parameters their definition and how they were obtained for these analysis.

Parameter	Definition	Where Obtained
C_t	Coefficient representing variations of watershed slope and storage	From Corps of Engineers*
L	Length of main stream channel miles	From U.S.G.S. 7.5 minute topographic
L_{ca}	Length on main stream to centroid of watershed	From U.S.G.S. 7.5 minute topographic
C_p	Peaking coefficient	From Corps of Engineers*
A	Watershed size	From U.S.G.S. 7.5 minute topographic

*Developed by the Corps of Engineers on a regional basis for Pennsylvania.

3. Routing. Reservoir routing is accomplished by using Modified Plus routing techniques where the flood hydrograph is routed through reservoir storage. Hydraulic capacities of the outlet works, spillways and the crest of the dam are used as outlet controls in the routing.

The hydraulic capacity of the outlet works can either be calculated and input or sufficient dimensions input and the program will calculate an elevation discharge relationship.

Storage in the pool area is defined by an area - elevation relationship from which the computer calculates storage. Surface areas are either planimetered from available mapping or U.S.G.S. 7.5 minute series topographic maps or taken from reasonably accurate design data.

4. Dam Overtopping. Using given percentages of the PMF the computer program will calculate the percentage of the PMF which can be controlled by the reservoir and spillway without the dam overtopping.

5. Dam Breach and Downstream Routing. The computer program is equipped to determine the increase in downstream flooding due to failure of the dam caused by overtopping. This is accomplished by routing both the pre failure peak flow and the peak flow through the breach (calculated by the computer with given input assumptions) at a given point in time and determining the water depth in the downstream channel. Channel cross-sections taken from U.S.G.S. 7.5 minute topographic maps were used in the downstream flood wave routing. Pre and post failure water depths are calculated at locations where cross-sections are input.

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG PENNSYLVANIA

DAM NAME BEAVER LAKE DAM
I.D. NUMBER 41-10
SHEET NO. 1 OF 5
BY OTM DATE 7-2-79

BEAVER LAKE DAM

DRAINAGE AREA

AREA = 2.96 mi^2 (FROM U.S.G.S. 7.5-MIN. QUAD.)

UNIT HYDROGRAPH PARAMETERS

DAMSITE LOCATED IN ZONE #17, SUSQUEHANNA RIVER BASIN. FROM CORPS OF ENGINEERS, BALTIMORE DISTRICT REGIONAL STUDY.

$C_p = 0.45$, $C_t = 1.13$

$L = 3.6$ mi , $L_{ca} = 1.3$ mi (FROM U.S.G.S. 7.5-MIN. QUAD.)

$t_p = C_t (L \times L_{ca})^{0.3} = 1.13 (3.6 \times 1.3)^{0.3}$

$t_p = 1.8$ HRS. (SNYDERS LAG (t_p) IN HRS.)

LOSS RATE AND BASE FLOW PARAMETERS

AS RECOMMENDED BY CORPS OF ENGINEERS, BALTIMORE DISTRICT.

STRTL = 1 INCH
CNSTL = 0.05 IN/HR
STRTQ = 1.5 cfs/mi^2
QRCSN = 0.05 (5% OF PEAK FLOW)
RTIOR = 2.00

PROBABLE MAXIMUM STORM

FROM HR No. 40
P.M.P. INDEX RAINFALL = 22.2 (0.99) = 22.0

$R_6 = 117\%$, $R_{12} = 127\%$, $R_{24} = 136\%$, $R_{48} = 143\%$, $R_{72} = 145\%$

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG PENNSYLVANIA

DAM NAME BEAVER LAKE DAM
I.D. NUMBER 41-10
SHEET NO. 2 OF 3
BY OTM DATE 7-2-79

ELEVATION-AREA-CAPACITY RELATIONSHIP

FROM U.S.G.S. 7.5-MIN. QUAD, FELO INSPECTION DATA, AND DER FILES.

AT SPILLWAY CREST, ELEV. 899.6'
AREA = 65 ACRES
INITIAL STORAGE = 368.3 AC.FT.

AT 920', AREA = 120 ACRES
AT 940', AREA = 165 ACRES
AT 960', AREA = 200 ACRES

ELEV. (FT.)	885	900	905	910	920	925	940	950	960
AREA (AC)	0	65	80	95	120	135	165	185	200

DISCHARGE RATING CURVE

DETERMINED BY (HEC-1).

SPILLWAY CREST ELEV. = 899.6'
LENGTH OF SPILLWAY = 19.0'
COEFFICIENT OF DISCHARGE = 3.2

OVERTOPPING PARAMETERS

TOP OF DAM (LOW SPOT) ELEV. = 899.8'
LENGTH = 750' (L_{MAX} = 750', V_{MAX} = 907')

L. ROBERT KIMBALL & ASSOCIATES
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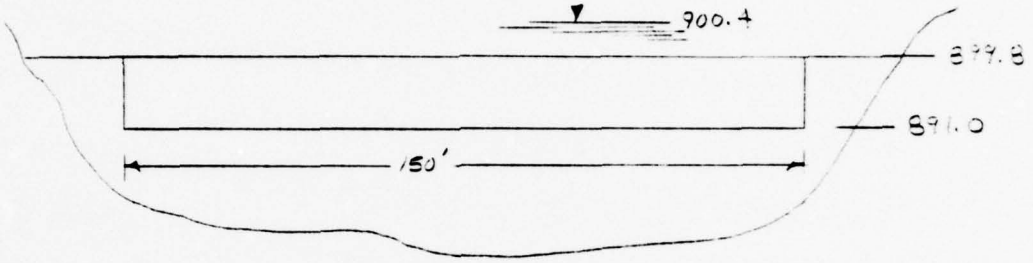
EBENSBURG PENNSYLVANIA

DAM NAME BEAVER LAKE DAM
I.D. NUMBER 41-10
SHEET NO. 3 OF 3
BY OTM DATE 7-2-79

DAM BREACH PARAMETERS



RATIO OF PMF	=	0.1
BREACH WIDTH	=	150'
SIDE SLOPE OF BREACH (Z)	=	0
FAILURE TIME	=	5 HRS
ELEV., FAILURE BEGINS	=	900.4'

CHANNEL ROUTING CROSS-SECTIONS OBTAINED FROM U.S.G.S. 7.5 MIN.- QUADS.

CHANNEL MANNING'S (n), QN(1) = 0.06, QN(2) = 0.05

CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 2.96 square mile (farmland and forested)

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 899.6 (370 ac-ft)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): N/A

ELEVATION MAXIMUM DESIGN POOL: Unknown

ELEVATION TOP DAM: 899.8

SPILLWAY CREST:

a. Elevation 899.6 presently
b. Type broad crested
c. Width 5 feet
d. Length 19 feet
e. Location Spillover Center of dam
f. Number and Type of Gates None

OUTLET WORKS:

a. Type None
b. Location
c. Entrance inverts
d. Exit inverts
e. Emergency draindown facilities

HYDROMETEOROLOGICAL GAUGES:

a. Type None
b. Location
c. Records

MAXIMUM NON-DAMAGING DISCHARGE: None

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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION  JULY 1978
  LAST MODIFICATION  26 FEB 79
**********
    1          A1       ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
    2          A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF BEAVER LAKE DAM
    3          A3       RATIOS OF PMF ROUTED THROUGH THE RESERVOIR  PA. 41410
    4          B        0    0    15    0    0    0    0    0    0    0
    5          B1       5
    6          J        1    3    1
    7          J1       .1   .5   1
    8
    9          INFLOW TO RESERVOIR
   10                                 2196                 3196
   11          P             22.0   117  127  136  143  145
   12          T                                          1.0  0.05
   13          W        1.8  0.45
   14                   210                 210
   15
   16          ROUTE THROUGH RESERVOIR
   17          Y                                1    1
   18          Y1       1                                  -899.6
   19          SA       0    65   80   95   120  135  165  185  200
   20                   899.8 901  910  920  925  940  950  960
   21                   10
   22                   110                 700
   23          SL       359  479  569  660  670  685  750
   24          SV  899.8    901  901.3 902.3 903  904  907
   25          K        99
```

FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 26 FEB 79

RUN DATE 10/07/211
TIME 10:41:11

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF BEAVER LAKE DAM
RATIOS OF PMF ROUTED THROUGH THE RESERVOIR (PAT 41910

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	15	0	0	0	0	0	0	0

JOPER	NWT	LROPT	TRACE
1	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 3 LRTIO= 1

RTIOS= 110 450 1100

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW TO RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
	1	2.96	0.00	2.96	0.00	0.000	0		0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	22.00	117.00	127.00	136.00	142.00	145.00	147.00

TRSPC COMPUTED BY THE PROGRAM IS .800

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.05	0.00	0.00

UNIT HYDROGRAPH DATA

TP= 1.80 CP= .53 NTAP= 0

RECESSION DATA

STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.00

APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC= 7.76 AND R= 11.38 (HOURS)

UNIT HYDROGRAPH 64 END-OF-PERIOD ORDINATES. LAG= 1.81 HOURS, CP= .53 VOL= 1.00

	21.	79.	161.	257.	352.	427.	474.	483.	456.	417.
	382.	349.	320.	293.	268.	245.	225.	206.	188.	172.
	158.	144.	132.	121.	111.	101.	93.	85.	78.	71.
	65.	59.	54.	49.	45.	41.	37.	34.	31.	28.
	26.	23.	21.	19.	18.	16.	15.	13.	12.	11.
	10.	9.	8.	7.	6.	6.	5.	4.	4.	4.

0 END-OF-PERIOD FLOW

MO	DA	HR	MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO	DA	HR	MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1	01	0	15	1	.00	0.00	.00	4.	1	02	12	15	141	.51	.50	.01	416.
1	01	0	30	2	.00	0.00	.00	4.	1	02	12	30	142	.51	.50	.01	456.
1	01	0	45	3	.00	0.00	.00	4.	1	02	12	45	143	.51	.50	.01	531.
1	01	1	00	4	.00	0.00	.00	3.	1	02	13	00	144	.51	.50	.01	649.
1	01	1	15	5	.00	0.00	.00	3.	1	02	13	15	145	.62	.61	.01	810.

1.01	1.30	6	.00	0.00	.00	3.	1.02	13.30	150	.62	.61	.01	1010.
1.01	1.45	7	.00	0.00	.00	3.	1.02	13.45	151	.62	.61	.01	1239.
1.01	2.00	8	.00	0.00	.00	3.	1.02	14.00	152	.62	.61	.01	1482.
1.01	2.15	9	.00	0.00	.00	2.	1.02	14.15	153	.77	.76	.01	1725.
1.01	2.30	10	.00	0.00	.00	2.	1.02	14.30	154	.77	.76	.01	1968.
1.01	2.45	11	.00	0.00	.00	2.	1.02	14.45	155	.77	.76	.01	2212.
1.01	3.00	12	.00	0.00	.00	2.	1.02	15.00	156	.77	.76	.01	2458.
1.01	3.15	13	.00	0.00	.00	2.	1.02	15.15	157	.78	.77	.01	2702.
1.01	3.30	14	.00	0.00	.00	2.	1.02	15.30	158	1.56	1.55	.01	2960.
1.01	3.45	15	.00	0.00	.00	2.	1.02	15.45	159	4.38	4.37	.01	3315.
1.01	4.00	16	.00	0.00	.00	1.	1.02	16.00	160	1.10	1.08	.01	3818.
1.01	4.15	17	.00	0.00	.00	1.	1.02	16.15	161	.72	.71	.01	4413.
1.01	4.30	18	.00	0.00	.00	1.	1.02	16.30	162	.72	.71	.01	5042.
1.01	4.45	19	.00	0.00	.00	1.	1.02	16.45	163	.72	.71	.01	5638.
1.01	5.00	20	.00	0.00	.00	1.	1.02	17.00	164	.72	.71	.01	6120.
1.01	5.15	21	.00	0.00	.00	1.	1.02	17.15	165	.57	.55	.01	6441.
1.01	5.30	22	.00	0.00	.00	1.	1.02	17.30	166	.57	.55	.01	6564.
1.01	5.45	23	.00	0.00	.00	1.	1.02	17.45	167	.57	.55	.01	6509.
1.01	6.00	24	.00	0.00	.00	1.	1.02	18.00	168	.57	.55	.01	6378.
1.01	6.15	25	.00	0.00	.00	1.	1.02	18.15	169	.04	.03	.01	6223.
1.01	6.30	26	.00	0.00	.00	1.	1.02	18.30	170	.04	.03	.01	6034.
1.01	6.45	27	.00	0.00	.00	1.	1.02	18.45	171	.04	.03	.01	5802.
1.01	7.00	28	.00	0.00	.00	1.	1.02	19.00	172	.04	.03	.01	5524.
1.01	7.15	29	.00	0.00	.00	1.	1.02	19.15	173	.04	.03	.01	5205.
1.01	7.30	30	.00	0.00	.00	1.	1.02	19.30	174	.04	.03	.01	4859.
1.01	7.45	31	.00	0.00	.00	1.	1.02	19.45	175	.04	.03	.01	4498.
1.01	8.00	32	.00	0.00	.00	0.	1.02	20.00	176	.04	.03	.01	4143.
1.01	8.15	33	.00	0.00	.00	0.	1.02	20.15	177	.04	.03	.01	3809.
1.01	8.30	34	.00	0.00	.00	0.	1.02	20.30	178	.04	.03	.01	3504.
1.01	8.45	35	.00	0.00	.00	0.	1.02	20.45	179	.04	.03	.01	3225.
1.01	9.00	36	.00	0.00	.00	0.	1.02	21.00	180	.04	.03	.01	2970.
1.01	9.15	37	.00	0.00	.00	0.	1.02	21.15	181	.04	.03	.01	2736.
1.01	9.30	38	.00	0.00	.00	0.	1.02	21.30	182	.04	.03	.01	2522.
1.01	9.45	39	.00	0.00	.00	0.	1.02	21.45	183	.04	.03	.01	2326.
1.01	10.00	40	.00	0.00	.00	0.	1.02	22.00	184	.04	.03	.01	2146.
1.01	10.15	41	.00	0.00	.00	0.	1.02	22.15	185	.04	.03	.01	1982.

1.01	10.30	42	.00	0.00	.00	0.	1.02	22.30	186	.04	.03	.01	1832.
1.01	10.45	43	.00	0.00	.00	0.	1.02	22.45	187	.04	.03	.01	1694.
1.01	11.00	44	.00	0.00	.00	0.	1.02	23.00	188	.04	.03	.01	1568.
1.01	11.15	45	.00	0.00	.00	0.	1.02	23.15	189	.04	.03	.01	1453.
1.01	11.30	46	.00	0.00	.00	0.	1.02	23.30	190	.04	.03	.01	1347.
1.01	11.45	47	.00	0.00	.00	0.	1.02	23.45	191	.04	.03	.01	1250.
1.01	12.00	48	.00	0.00	.00	0.	1.03	0.00	192	.04	.03	.01	1162.
1.01	12.15	49	.03	0.00	.03	0.	1.03	.15	193	.00	0.00	.00	1080.
1.01	12.30	50	.03	0.00	.03	0.	1.03	.30	194	.00	0.00	.00	1004.
1.01	12.45	51	.03	0.00	.03	0.	1.03	.45	195	.00	0.00	.00	932.
1.01	13.00	52	.03	0.00	.03	0.	1.03	1.00	196	.00	0.00	.00	863.
1.01	13.15	53	.03	0.00	.03	0.	1.03	1.15	197	.00	0.00	.00	796.
1.01	13.30	54	.03	0.00	.03	0.	1.03	1.30	198	.00	0.00	.00	733.
1.01	13.45	55	.03	0.00	.03	0.	1.03	1.45	199	.00	0.00	.00	672.
1.01	14.00	56	.03	0.00	.03	0.	1.03	2.00	200	.00	0.00	.00	615.
1.01	14.15	57	.04	0.00	.04	0.	1.03	2.15	201	.00	0.00	.00	563.
1.01	14.30	58	.04	0.00	.04	0.	1.03	2.30	202	.00	0.00	.00	515.
1.01	14.45	59	.04	0.00	.04	0.	1.03	2.45	203	.00	0.00	.00	471.
1.01	15.00	60	.04	0.00	.04	0.	1.03	3.00	204	.00	0.00	.00	431.
1.01	15.15	61	.04	0.00	.04	0.	1.03	3.15	205	.00	0.00	.00	395.
1.01	15.30	62	.08	0.00	.08	0.	1.03	3.30	206	.00	0.00	.00	361.
1.01	15.45	63	.23	0.00	.23	0.	1.03	3.45	207	.00	0.00	.00	330.
1.01	16.00	64	.06	0.00	.06	0.	1.03	4.00	208	.00	0.00	.00	308.
1.01	16.15	65	.04	0.00	.04	0.	1.03	4.15	209	.00	0.00	.00	287.
1.01	16.30	66	.04	0.00	.04	0.	1.03	4.30	210	.00	0.00	.00	268.
1.01	16.45	67	.04	.02	.02	0.	1.03	4.45	211	.00	0.00	.00	250.
1.01	17.00	68	.04	.02	.01	2.	1.03	5.00	212	.00	0.00	.00	233.
1.01	17.15	69	.03	.02	.01	5.	1.03	5.15	213	.00	0.00	.00	218.
1.01	17.30	70	.03	.02	.01	11.	1.03	5.30	214	.00	0.00	.00	203.
1.01	17.45	71	.03	.02	.01	18.	1.03	5.45	215	.00	0.00	.00	189.
1.01	18.00	72	.03	.02	.01	26.	1.03	6.00	216	.00	0.00	.00	177.
1.01	18.15	73	.00	0.00	.00	34.	1.03	6.15	217	.00	0.00	.00	165.
1.01	18.30	74	.00	0.00	.00	41.	1.03	6.30	218	.00	0.00	.00	154.
1.01	18.45	75	.00	0.00	.00	46.	1.03	6.45	219	.00	0.00	.00	144.
1.01	19.00	76	.00	0.00	.00	48.	1.03	7.00	220	.00	0.00	.00	134.
1.01	19.15	77	.00	0.00	.00	48.	1.03	7.15	221	.00	0.00	.00	125.

1.01	19.30	78	.00	0.00	.00	47.	1.03	7.30	222	.00	0.00	.00	117.
1.01	19.45	79	.00	0.00	.00	44.	1.03	7.45	223	.00	0.00	.00	109.
1.01	20.00	80	.00	0.00	.00	40.	1.03	8.00	224	.00	0.00	.00	102.
1.01	20.15	81	.00	0.00	.00	37.	1.03	8.15	225	.00	0.00	.00	95.
1.01	20.30	82	.00	0.00	.00	34.	1.03	8.30	226	.00	0.00	.00	88.
1.01	20.45	83	.00	0.00	.00	31.	1.03	8.45	227	.00	0.00	.00	82.
1.01	21.00	84	.00	0.00	.00	28.	1.03	9.00	228	.00	0.00	.00	77.
1.01	21.15	85	.00	0.00	.00	26.	1.03	9.15	229	.00	0.00	.00	72.
1.01	21.30	86	.00	0.00	.00	24.	1.03	9.30	230	.00	0.00	.00	67.
1.01	21.45	87	.00	0.00	.00	22.	1.03	9.45	231	.00	0.00	.00	63.
1.01	22.00	88	.00	0.00	.00	20.	1.03	10.00	232	.00	0.00	.00	58.
1.01	22.15	89	.00	0.00	.00	18.	1.03	10.15	233	.00	0.00	.00	54.
1.01	22.30	90	.00	0.00	.00	17.	1.03	10.30	234	.00	0.00	.00	51.
1.01	22.45	91	.00	0.00	.00	15.	1.03	10.45	235	.00	0.00	.00	47.
1.01	23.00	92	.00	0.00	.00	14.	1.03	11.00	236	.00	0.00	.00	44.
1.01	23.15	93	.00	0.00	.00	13.	1.03	11.15	237	.00	0.00	.00	41.
1.01	23.30	94	.00	0.00	.00	12.	1.03	11.30	238	.00	0.00	.00	38.
1.01	23.45	95	.00	0.00	.00	11.	1.03	11.45	239	.00	0.00	.00	36.
1.02	0.00	96	.00	0.00	.00	10.	1.03	12.00	240	.00	0.00	.00	33.
1.02	.15	97	.03	.01	.01	9.	1.03	12.15	241	.01	0.00	.01	31.
1.02	.30	98	.03	.01	.01	10.	1.03	12.30	242	.01	0.00	.01	29.
1.02	.45	99	.03	.01	.01	11.	1.03	12.45	243	.01	0.00	.01	27.
1.02	1.00	100	.03	.01	.01	14.	1.03	13.00	244	.01	0.00	.01	25.
1.02	1.15	101	.03	.01	.01	18.	1.03	13.15	245	.01	0.00	.01	24.
1.02	1.30	102	.03	.01	.01	24.	1.03	13.30	246	.01	0.00	.01	22.
1.02	1.45	103	.03	.01	.01	30.	1.03	13.45	247	.01	0.00	.01	21.
1.02	2.00	104	.03	.01	.01	36.	1.03	14.00	248	.01	0.00	.01	19.
1.02	2.15	105	.03	.01	.01	42.	1.03	14.15	249	.01	0.00	.01	18.
1.02	2.30	106	.03	.01	.01	48.	1.03	14.30	250	.01	0.00	.01	17.
1.02	2.45	107	.03	.01	.01	52.	1.03	14.45	251	.01	0.00	.01	16.
1.02	3.00	108	.03	.01	.01	57.	1.03	15.00	252	.01	0.00	.01	15.
1.02	3.15	109	.03	.01	.01	61.	1.03	15.15	253	.01	0.00	.01	14.
1.02	3.30	110	.03	.01	.01	65.	1.03	15.30	254	.02	.01	.01	13.
1.02	3.45	111	.03	.01	.01	68.	1.03	15.45	255	.06	.05	.01	12.
1.02	4.00	112	.03	.01	.01	72.	1.03	16.00	256	.02	.00	.01	11.
1.02	4.15	113	.03	.01	.01	75.	1.03	16.15	257	.01	0.00	.01	11.

1.02	4.30	114	.03	.01	.01	77.	1.03	16.30	258	.01	0.00	.01	18.
1.02	4.45	115	.03	.01	.01	80.	1.03	16.45	259	.01	0.00	.01	24.
1.02	5.00	116	.03	.01	.01	82.	1.03	17.00	260	.01	0.00	.01	28.
1.02	5.15	117	.03	.01	.01	84.	1.03	17.15	261	.01	0.00	.01	31.
1.02	5.30	118	.03	.01	.01	86.	1.03	17.30	262	.01	0.00	.01	32.
1.02	5.45	119	.03	.01	.01	88.	1.03	17.45	263	.01	0.00	.01	30.
1.02	6.00	120	.03	.01	.01	89.	1.03	18.00	264	.01	0.00	.01	28.
1.02	6.15	121	.07	.06	.01	92.	1.03	18.15	265	.00	0.00	.00	26.
1.02	6.30	122	.07	.06	.01	97.	1.03	18.30	266	.00	0.00	.00	24.
1.02	6.45	123	.07	.06	.01	105.	1.03	18.45	267	.00	0.00	.00	23.
1.02	7.00	124	.07	.06	.01	119.	1.03	19.00	268	.00	0.00	.00	21.
1.02	7.15	125	.07	.06	.01	136.	1.03	19.15	269	.00	0.00	.00	20.
1.02	7.30	126	.07	.06	.01	157.	1.03	19.30	270	.00	0.00	.00	18.
1.02	7.45	127	.07	.06	.01	180.	1.03	19.45	271	.00	0.00	.00	17.
1.02	8.00	128	.07	.06	.01	204.	1.03	20.00	272	.00	0.00	.00	16.
1.02	8.15	129	.07	.06	.01	226.	1.03	20.15	273	.00	0.00	.00	15.
1.02	8.30	130	.07	.06	.01	246.	1.03	20.30	274	.00	0.00	.00	14.
1.02	8.45	131	.07	.06	.01	264.	1.03	20.45	275	.00	0.00	.00	13.
1.02	9.00	132	.07	.06	.01	281.	1.03	21.00	276	.00	0.00	.00	12.
1.02	9.15	133	.07	.06	.01	297.	1.03	21.15	277	.00	0.00	.00	11.
1.02	9.30	134	.07	.06	.01	311.	1.03	21.30	278	.00	0.00	.00	11.
1.02	9.45	135	.07	.06	.01	324.	1.03	21.45	279	.00	0.00	.00	10.
1.02	10.00	136	.07	.06	.01	336.	1.03	22.00	280	.00	0.00	.00	9.
1.02	10.15	137	.07	.06	.01	347.	1.03	22.15	281	.00	0.00	.00	9.
1.02	10.30	138	.07	.06	.01	357.	1.03	22.30	282	.00	0.00	.00	8.
1.02	10.45	139	.07	.06	.01	366.	1.03	22.45	283	.00	0.00	.00	7.
1.02	11.00	140	.07	.06	.01	374.	1.03	23.00	284	.00	0.00	.00	7.
1.02	11.15	141	.07	.06	.01	382.	1.03	23.15	285	.00	0.00	.00	6.
1.02	11.30	142	.07	.06	.01	389.	1.03	23.30	286	.00	0.00	.00	6.
1.02	11.45	143	.07	.06	.01	395.	1.03	23.45	287	.00	0.00	.00	6.
1.02	12.00	144	.07	.06	.01	401.	1.04	0.00	288	.00	0.00	.00	5.
									SUM	25.52	22.91	2.61	175854.
										(648.1)	(582.1)	(66.1)	(4979.63)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME

4413.	5043.	5638.	6120.	6441.	6564.	6509.	6378.	6223.	6034.
5602.	5524.	5205.	4859.	4498.	4143.	3809.	3504.	3225.	2970.
2736.	2522.	2326.	2146.	1982.	1832.	1694.	1568.	1453.	1347.
1250.	1162.	1080.	1004.	932.	863.	796.	733.	672.	615.
563.	515.	471.	431.	395.	361.	330.	308.	287.	268.
250.	233.	218.	203.	189.	177.	165.	156.	144.	134.
125.	117.	109.	102.	96.	88.	82.	77.	72.	67.
63.	58.	54.	51.	47.	44.	41.	38.	36.	33.
31.	29.	27.	25.	24.	22.	21.	19.	18.	17.
16.	15.	14.	13.	12.	11.	11.	18.	24.	28.
31.	32.	30.	28.	26.	24.	23.	21.	20.	18.
17.	16.	15.	14.	13.	12.	11.	11.	10.	9.
9.	8.	7.	7.	6.	6.	6.	5.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	6564.	4821.	1783.	611.	175849.
CMS	186.	137.	50.	17.	4979.
INCHES		15.15	22.41	23.03	23.03
MM		384.87	569.17	584.87	584.87
AC-FT		2291.	35361.	36331.	36331.
THOUS CU M		2949.	4361.	4482.	4482.

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HYDROGRAPH ROUTING

ROUTE THROUGH RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR

0.0	0.000	0.00	1	1	0	0		0
NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT	
1	0	0	0.000	0.000	0.000	-900.	0	

SURFACE AREA=	0.	65.	80.	95.	120.	135.	165.	185.	200.
CAPACITY=	0.	370.	761.	1198.	2271.	2908.	5154.	6903.	8828.
ELEVATION=	883.	900.	905.	910.	920.	925.	940.	950.	960.

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
899.6	19.0	3.2	1.5	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
899.8	3.0	1.5	750.

CREST LENGTH AT OR BELOW	359.	479.	569.	660.	670.	685.	700.
ELEVATION	899.8	901.0	901.3	902.3	903.0	904.0	907.0

STATION 2, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .10	RATIO 2 .50	RATIO 3 1.00
HYDROGRAPH AT	1	2.96 (7.67)	1	636. (18.59)	3282. (92.93)	6564. (185.87)
ROUTED TO	2	2.96 (7.67)	1	623. (17.65)	3226. (91.35)	6507. (184.26)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	899.60	899.60	899.80
STORAGE	370.	370.	384.
OUTFLOW	0.	0.	5.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	900.42	.62	425.	623.	27.50	42.25	0.00
.50	901.54	1.74	902.	3226.	43.75	41.75	0.00
1.00	902.40	2.60	563.	6507.	49.75	41.75	0.00

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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION     JULY 1978
  LAST MODIFICATION  26 FEB 79
**********
     1          A1      RATIO OF PMF ROUTED THROUGH THE RESERVOIR AND DOWNSTREAM
     2          A2      DOWNSTREAM CONDITION DUE TO OVERTOP...BEAVER LAKE...PA 41-10
     3          A3      PLAN 1 ASSUMES BREACH. PLAN 2 ASSUMES NO BREACH
     4          B   288      0      15       0       0       0       0       0       0       0
     5          B1    5
     6          J     2      1       1
     7          J1   .1
     8          K     0      1                                                       1
     9          K2       INFLOW TO RESERVOIR
    10          M     1      1    2.96               2.96                                    1
    11          P          22.0     117     127     136     143     145
    12          T                                                  1.0    0.05
    13          W   1.8    0.45
    14          X  -1.8    .05     2.0
    15          K     1      2                                                       1
    16          K1       ROUTE THROUGH RESERVOIR
    17          Y                                          1       1
    18          Y1    1                                                    -899.6
    19          SA    0      65      80      95     120     135     165     185     200
    20          SE 882.5  899.6     905     910     920     925     940     950     960
    21          SS 899.6     10     3.2     1.8                                     1
    22          SD 899.8    3.0     1.5     750
    23          SL   359     479     569     660     670     685     750
    24          SV 899.8     901   901.3   902.3     903     904     907
    25          SB   150       0     891       5   899.6   900.4
    26          SB   150       0     891       5   899.6     903
    27          K     1      3                                                       1
    28          K1       CHANNEL ROUTING - MOD PULS REACH 2-3
    29          Y                                          1       1
    30          Y1    1
    31          Y6  .06     .05     .06     879     920    3000  0.0133
    32          Y7    0     920     150     900     345     880     350     879     355     879
```

```
33          Y7   360     880     .475    900     .650    920
34          K     1       4                                       1
35          K1        CHANNEL ROUTING - MOD PULS REACH 3-4
36          Y                                     1       1
37          Y1    1
38          Y6   .06     .05     .06     839     880    8000  0.0050
39          Y7    0      880     300     860     490     840     465     839     475     839
40          Y7   490     840     650     860     750     880
41          K     1       5                                       1
42          K1        CHANNEL ROUTING - MOD PULS REACH 4-5
43          Y                                     1       1
44          Y1    1
45          Y6   .06     .05     .06     779     840    5000  0.0080
46          Y7    0      840      50     820     200     800     238     779     840     779
47          Y7   280     800     300     820     400     840
48          K    99
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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION.  JULY 1978
  LAST MODIFICATION  26 FEB 79
**********

RUN  DATE  79/08/01.
     TIME  18.17.02.
```

RATIO OF PMF ROUTED THROUGH THE RESERVOIR AND DOWNSTREAM
DOWNSTREAM CONDITION DUE TO OVERTOP...BEAVER LAKE...PA 41-10
PLAN 1 ASSUMES BREACH, PLAN 2 ASSUMES NO BREACH

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	15	0	0	0	0	0	0	0

JOPER	NWT	LROPT	TRACE
0	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 2 NRTIO= 1 LRTIO= 1

RTIOS= 1.0

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SUB-AREA RUNOFF COMPUTATION

INFLOW TO RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	2.96	0.00	2.96	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	22.00	117.00	127.00	136.00	143.00	148.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .800

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.05	0.00	0.00

UNIT HYDROGRAPH DATA

TP= 1.80 CP= .45 NTA= 0

RECESSION DATA

STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.00

APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC= 7.75 AND R=11.32 INTERVALS

UNIT HYDROGRAPH 64 END-OF-PERIOD ORDINATES, LAG= 1.81 HOURS, CP= .69 VOL= 1.00

21.	79.	161.	257.	352.	427.	474.	483.	456.	417.	
382.	349.	320.	293.	268.	245.	225.	206.	188.	172.	
158.	144.	132.	121.	111.	101.	93.	85.	78.	71.	
[illegible]	60.	55.	50.	46.	42.	38.	35.	32.	29.	
[illegible]	25.	23.	21.	19.	17.	16.	14.	13.	12.	
[illegible]	10.	9.	9.	8.	7.	7.	6.	6.	5.	
5.	4.	4.	4.							

0

END-OF-PERIOD FLOW

HO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	HO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.15	1	.00	0.00	.00	4.	1.02	12.15	145	.51	.50	.01	416.
1.01	.30	2	.00	0.00	.00	4.	1.02	12.30	146	.51	.50	.01	456.
1.01	.45	3	.00	0.00	.00	4.	1.02	12.45	147	.51	.50	.01	531.
1.01	1.00	4	.00	0.00	.00	3.	1.02	13.00	148	.51	.50	.01	649.
1.01	1.15	5	.00	0.00	.00	3.	1.02	13.15	149	.62	.61	.01	810.

3.	3.	3.	3.	3.	2.	2.	2.	2.	2.
2.	2.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	6356.	482.	178.	61.	17585.
CMS	180.	14.	5.	2.	498.
INCHES		1.52	2.24	2.30	2.30
MM		38.49	56.92	58.49	58.49
AC-FT		239.	354.	363.	363.
THOUS CU M		295.	436.	448.	448.

PLAN 8 SAME AS PLAN 1

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HYDROGRAPH ROUTING

ROUTE THROUGH RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-900.	0

SURFACE AREA=	0.	65.	80.	95.	120.	135.	165.	185.	200.
CAPACITY=	0.	370.	761.	1198.	2271.	2908.	5154.	6903.	8828.

ELEVATION=	883.	900.	905.	910.	920.	925.	940.	950.	960.

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
899.6	19.0	3.2	1.5	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
899.8	3.0	1.5	750.

CREST LENGTH	359.	479.	569.	660.	670.	685.	750.
AT OR BELOW ELEVATION	899.8	901.0	901.3	902.3	903.0	904.0	907.0

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
150.	0.00	891.00	5.00	899.60	900.40

STATION 2, PLAN 1, RATIO 1

BEGIN DAM FAILURE AT 41.75 HOURS

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

INCHES	1.49	2.19	2.23	2.23
MM	37.73	55.61	56.72	56.72
AC-FT	234.	345.	352.	352.
THOUS CU M	289.	426.	435.	435.

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HYDROGRAPH ROUTING

CHANNEL ROUTING 4 MOD PULS REACH 2-3

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
3	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0.0	0.000	0.000	0.000	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELMVT	ELMAX	RLNTH	SEL
.0600	.0500	.0600	879.0	920.0	3000.	.01330

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

	0.00	920.00	150.00	900.00	345.00	880.00	350.00	879.00	355.00	879.00
	360.00	880.00	475.00	900.00	650.00	920.00				
STORAGE	0.00	2.60	9.98	22.34	39.66	61.95	89.22	121.45	158.66	
200.84	247.99	300.30	357.81	420.54	488.48	561.63	639.99	723.56	812.34	
906.34										
OUTFLOW	0.00	159.77	851.14	2345.70	4876.19	8651.05	13862.29	20689.75	29303.73	
39866.74	52503.13	67363.39	84702.51	104657.59	127366.82	152967.62	181595.74	213384.89	248466.64	
286970.34										
STAGE	879.00	881.16	883.32	885.47	887.63	889.79	891.95	894.11	896.26	
898.42	900.58	902.74	904.89	907.05	909.21	911.37	913.53	915.68	917.84	
920.00										
FLOW	0.00	159.77	851.14	2345.70	4876.19	8651.05	13862.29	20689.75	29303.73	
39866.74	52503.13	67363.39	84702.51	104657.59	127366.82	152967.62	181595.74	213384.89	248466.64	
286970.34										

STATION 3, PLAN 1, RTIO 1

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

881.8	881.7	881.6	881.5	881.5	881.4	881.4	881.3	881.3	881.2
881.8	881.2	881.0	880.9	880.8	880.7	880.6	880.5	880.4	880.3
880.2	880.1	880.0	880.0	879.9	879.8	879.8	879.7	879.7	879.6
879.6	879.5	879.5	879.5	879.4	879.4	879.4	879.4	879.3	879.3
879.3	879.3	879.3	879.3	879.2	879.2	879.2	879.2	879.2	879.2
879.2	879.2	879.2	879.2	879.1	879.1	879.1	879.1	879.1	879.1
879.1	879.1	879.1	879.1	879.1	879.1	879.1	879.1	879.1	879.1
879.1	879.1	879.1	879.1	879.1	879.1	879.1	879.1	879.1	879.1
879.1	879.1	879.1	879.1	879.1	879.1	879.1	879.1	879.1	879.1
879.1	879.1	879.1	879.1	879.1	879.1	879.1	879.1		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	6216.	472.	174.	59.	1705.
CMS	18.	13.	5.	2.	48.
INCHES		1.48	2.19	2.23	2.23
MM		37.68	55.60	56.71	56.71
AC-FT		294.	348.	352.	352.
THOUS CU M		363.	426.	434.	434.

MAXIMUM STORAGE = 8.

MAXIMUM STAGE IS 882.4

****

HYDROGRAPH ROUTING

CHANNEL ROUTING - MOD PULS REACH 3-4

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO

4	1	0	0	0	0	1	0	0	

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.10600	.10300	.10600	839.0	880.0	80001.	.100500

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 880.00 300.00 860.00 450.00 840.00 465.00 839.00 475.00 839.00

.990100 .840100 .850100 .860100 .750100 .880100

STORAGE	0.00	10.01	44.60	87.85	143.85	213.71	298.33	391.39	500.52
622.90									
	758.67	910.52	1079.48	1265.53	1468.69	1688.95	1926.32	2180.79	2452.37
2741.05									
OUTFLOW	0.00	233.31	1036.22	2307.38	4164.53	7920.70	12081.50	17355.24	23834.56
31016.04									
	40661.22	50989.26	63112.59	77115.00	93092.44	111145.53	131376.21	153886.20	178776.22
206145.69									
STAGE	839.00	841.16	843.32	845.47	847.63	849.79	851.95	854.11	856.26

858.42	860.58	862.74	864.89	867.05	869.21	871.37	873.53	875.68	877.84
880.00									
FLOW	0.00	233.31	1036.22	2507.38	4764.53	7920.70	12083.40	17355.24	23834.56
31616.04	40661.32	50989.26	63112.59	77116.00	93092.44	111145.53	131376.21	153886.20	178776.22
206145.69									

STATION 4, PLAN 1, RTIO 1

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1.	1.	1.	1.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1.	1.	1.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	2.	2.	2.	2.	3.	[illegible]	[illegible]	[illegible]	4.
4.	4.	5.	6.	7.	9.	11.	14.	17.	21.
26.	33.	42.	53.	67.	83.	101.	122.	146.	171.
199.	231.	288.	345.	402.	456.	506.	570.	682.	830.
[illegible]	1129.	1285.	1424.	1530.	1595.	1620.	[illegible]	[illegible]	1505.
[illegible]	1341.	1249.	1155.	1061.	981.	905.	804.	[illegible]	503.
382.	294.	234.	208.	189.	166.	150.	[illegible]	[illegible]	112.
103.	94.	86.	79.	73.	67.	61.	57.	52.	48.
44.	41.	38.	35.	33.	31.	28.	27.	25.	23.
22.	20.	19.	18.	17.	16.	15.	14.	13.	12.
11.	11.	10.	9.	9.	8.	8.	[illegible]	7.	7.

CMS	17.	13.	5.	2.	482.
INCHES		1.47	2.19	2.23	2.23
MM		37.22	55.57	56.67	56.67
AC-FT		231.	345.	352.	352.
THOUS CU M		285.	426.	434.	434.

MAXIMUM STORAGE = 29.

MAXIMUM STAGE IS 84.12

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

CHANNEL ROUTING - MOD. PULS REACH A-B

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
5	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0600	.0500	.0600	779.0	840.0	5000.	.00800

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 840.00 50.00 820.00 200.00 800.00 235.00 779.00 245.00 779.00
280.00 800.00 300.00 820.00 400.00 840.00

STORAGE	0.00	5.66	15.26	28.80	46.29	67.72	93.10	123.06	162.19
211.37									
	270.61	339.91	419.26	508.64	607.24	714.72	833.07	956.29	1090.39
1233.36									
OUTFLOW	0.00	221.69	863.11	2030.37	3831.76	6368.28	9734.75	14533.20	21177.28
29432.33									
	39559.13	51785.92	66322.33	83515.54	104059.83	127541.56	154017.75	183594.02	216389.45
252527.30									
STAGE	779.00	782.21	785.42	788.63	791.84	795.05	798.26	801.47	804.68
807.89									
	811.11	814.32	817.53	820.74	823.95	827.16	830.37	833.58	836.79
840.00									
FLOW	0.00	221.69	863.11	2030.37	3831.76	6368.28	9734.75	14533.20	21177.28
29432.33									
	39559.13	51785.92	66322.33	83515.54	104059.83	127541.56	154017.75	183594.02	216389.45
252527.30									

STATION 51 PLAN 1, RTIO 1

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO APPLIED TO FLOWS 1 .10
HYDROGRAPH AT	1	2.96 (7.67)	1	656. (18.59)
			2	656. (18.59)
ROUTED TO	2	2.96 (7.67)	1	1662. (47.07)
			2	623. (17.65)
ROUTED TO	3	2.96 (7.67)	1	1657. (46.92)
			2	621. (17.59)
ROUTED TO	4	2.96 (7.67)	1	1620. (45.86)
			2	607. (17.18)
ROUTED TO	5	2.96 (7.67)	1	1613. (45.68)
			2	605. (17.13)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ••••••••••••••••

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	899.60	899.60	899.80
STORAGE	370.	370.	384.
OUTFLOW	0.	0.	0.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	900.41	.61	424.	1662.	71.83	81.[illegible]	81.75

PLAN 2 ••••••••••••••••

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	899.60	899.60	899.80
STORAGE	370.	370.	[illegible]
OUTFLOW	0.	0.	0.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	900.68	.68	428.	683.	37.50	[illegible]	0.00

PLAN 1 STATION 3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	1657.	884.5	44.00

PLAN 2 STATION 3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	621.	882.6	42.50

PLAN 1 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	1620.	844.2	44.25

PLAN 2 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	607.	842.2	43.00

PLAN 1 STATION 5

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	1613.	787.5	44.50

PLAN 2 STATION 5

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	605.	784.1	43.00

APPENDIX E

DRAWINGS

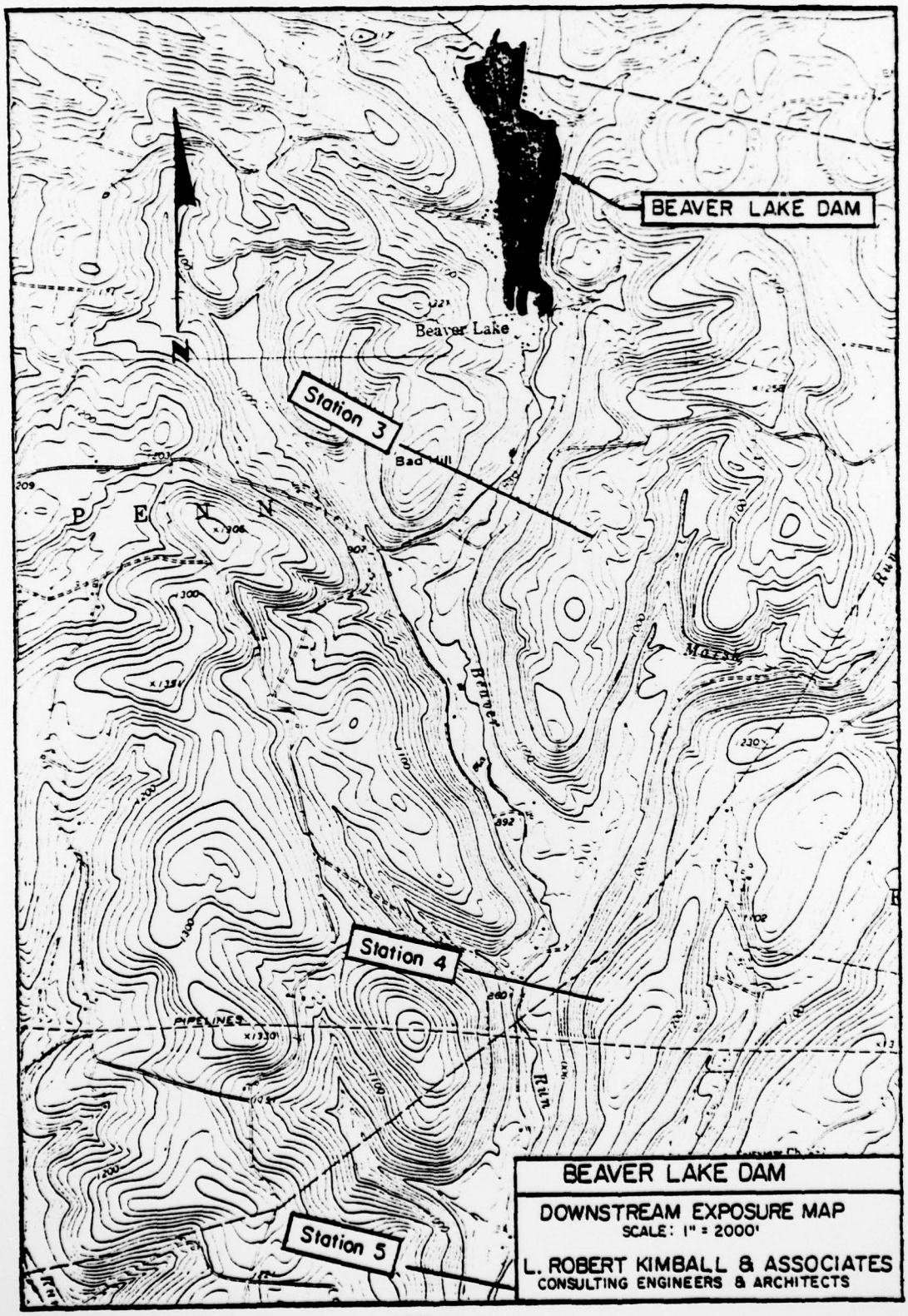

BEAVER LAKE DAM
Beaver Lake
Station 3
Station 4
Station 5
PENN
PIPELINES
BEAVER LAKE DAM
DOWNSTREAM EXPOSURE MAP
SCALE: 1" = 2000'
L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS

FIGURE 1

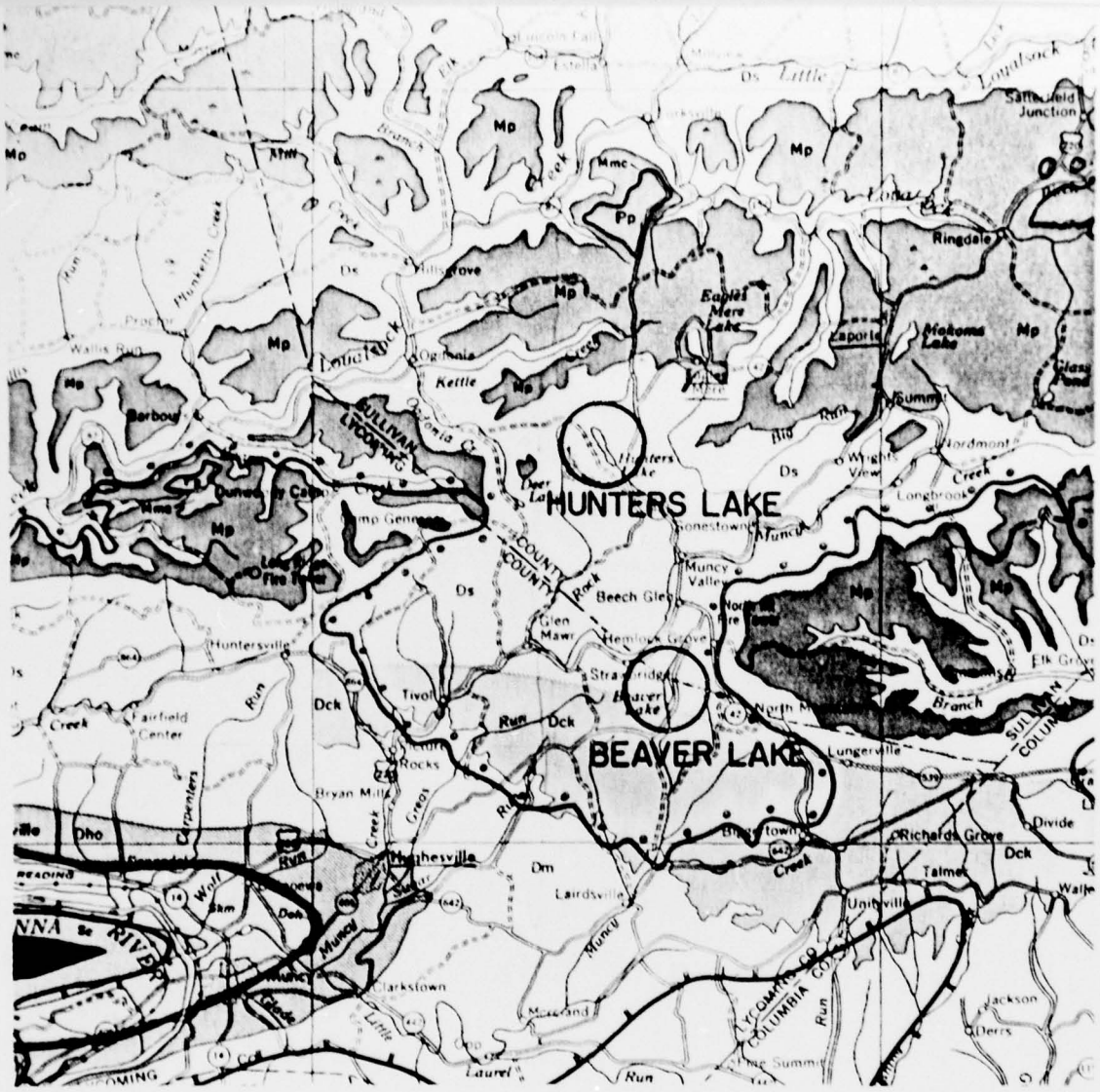
APPENDIX F

GEOLOGY

General Geology

Beaver Lake Dam lies within the Allegheny High Plateaus Section of the Applachian Plateaus Physiographic Province. This area is characterized by nearly horizontal strata with local open folds. Anticlines and synclines are usually quite broad.

The bedrock under Beaver Lake consists of the Devonian aged Susquehanna Group. This is a complex unit of sandstones, siltstones, shales and conglomerates. Usually the following changes occur from the bottom to the top of the group: the sediment grain size increases, the average thickness of the beds increases, the shales become redder, and the percentage of silica increases. The bedding is usually well developed with thicknesses ranging from less than one to over fifteen feet. The joints are usually closely spaced in a well developed regular pattern in the shales and siltstones. The shales weather rapidly, while the sandstones, siltstones and conglomerates are moderately resistant. This group can form a good foundation for heavy structures if it is excavated to sound material and the shales and siltstones are kept water free. The surface drainage is moderate to good, except in glaciated regions where it is poor. The interstitial porosity is low in the coarser rocks while the joint development allows a medium quantity of total effective porosity.



GEOLOGIC MAP OF HUNTERS LAKE AND BEAVER LAKE DAM AREA

Oswayo Formation

Brownish and greenish gray, fine and medium grained sandstones with some shales and scattered calcareous lenses, includes red shales which become more numerous eastward. Relation to type Oswayo not proved.

Catskill Formation

Chiefly red to brownish shales and sandstone; includes gray and greenish sandstone tongues named Elk Mountain, Honesdale, Shohola, and Delaware River to the east.

Marine beds

Gray to olive brown shales, graywackes, and sandstones, contains "Chemung" beds and "Portage" beds including Bucket, Shafter, Burrell, and Trimmers Rock. Fully transitional at base.

Susquehanna Group

Barbed line is "Chemung-Catskill" contact of Second Pennsylvania Survey. County reports, Sus. on "Chemung" side of line.

Scale: 1:250,000